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INSTRUCTION MANUAL

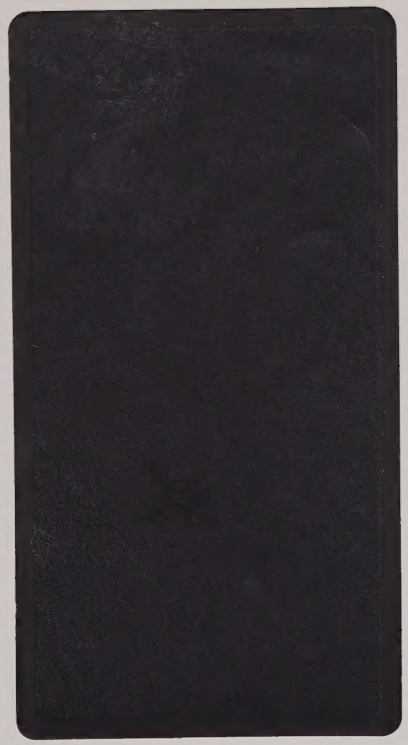
MODEL 106

WIDEBAND AMPLIFIER

MODEL 107

PULSE AMPLIFIER

KEITHLEY INSTRUMENTS



INSTRUCTION MANUAL

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WIDEBAND AMPLIFIER

MODEL 107

PULSE AMPLIFIER

TABLE OF CONTENTS

Section		Page
1.	GENERAL DESCRIPTION	1
1-1.	General	1
1-2.	Applications	1
1-3.	Models 106, 107 Differences	1
1-4.	Accessories	1
1-5.	Specifications	2
1-6.	Equipment Shipped	3
2.	OPERATION	5
2-1.	Front Panel Controls and Terminals	5
2-2.	Rear Panel Controls and Terminals	5
2-3.	Operating Procedures	5
2-4.	Cascading	6
2-5.	Gains Other Than 10, 100, 1000 and 10,000	7
2-6.	Open Circuit Operation	7
2-7.	Amplifier Noise	7
2-8.	Rise Time	8
2-9.	Delay Time	8
2-10.	Ground Loops	8
2-11.	Stray Fields	8
2-12.	234-Volt Operation	8
3.	CIRCUIT DESCRIPTION	9
3-1.	General	9
3-2.	Amplifier Design	9
3-3.	Power Supply	10
4.	SERVICING	11
4-1.	General	11
4-2.	Servicing Schedule	11
4-3.	Parts Replacement	11
4-4.	Troubleshooting	11
5.	CALIBRATION	13
5-1.	General	13
5-2.	Calibration Schedule	14
5-3.	Models 106, 107 Low-Frequency Calibration	14
5-4.	Model 106 High-Frequency Calibration	15
5-5.	Model 107 High-Frequency Calibration	16
5-6.	Low-Frequency Response Check	17
6.	ACCESSORIES	21
6-1.	Model 1042 Accessory Kit	21
6-2.	Model 4001 Rack Mounting Kit	21
7.	REPLACEABLE PARTS	23
7-1.	Replaceable Parts List	23
7-2.	How to Order Parts	23
7-3.	Circuit Designations	23
	Models 106, 107 Replaceable Parts List	24
	Models 106, 107 Schematic Diagram 17715D	29
*	Change Notice	Last Page

* Yellow Change Notice sheet is included only for instrument modifications affecting the Instruction Manual.

SECTION 1. GENERAL DESCRIPTION

1-1. GENERAL. The Keithley Models 106 and 107 contain three separate low-noise X10 gain amplifiers. The Model 106 is tuned for a wideband frequency response; the Model 107 is tuned for pulse response. (See Figures 11 and 12 for illustrations of the two responses.) A total gain of 1000 can be obtained by cascading amplifiers. Any of the amplifiers can be used separately and/or simultaneously.

a. The bandwidth of each Model 106 Amplifier is from 1 kc to 180 Mc (-3db). The low-frequency 3-db point reduces its sensitivity to line frequency interference. Response from 2.5 kc to 150 Mc is flat ±0.5 db. Voltage gain of one amplifier module is 10 (20db) when terminated into a 50-ohm load. The input impedance is 50 ohms. Noise referred to the input is less than 30 microvolts rms, regardless of gain. Greater than 80-db isolation between amplifiers at 100 Mc allows them to be used individually for multi-channel operation.

b. Each amplifier in the Model 107 Pulse Amplifier has a rise time of less than 3 nanoseconds (10% to 90%). Overshoot is less than 2%, pulse width for a 10% droop is 30 microseconds. Other specifications are the same as for the Model 106.

1-2. APPLICATIONS.

a. The Model 106 Wideband Amplifier is used as a general laboratory pre-amplifier in audio, radar, IF, TV and VHF work. It can be used with all types of oscilloscopes, spectrum analyzers and counters. Its low noise permits amplification of signals in the microvolt region at low and high frequencies.

b. The Model 107 Pulse Amplifier is designed to amplify non-sinusoidal wave forms with a fast rise time, minimum overshoot and minimum ringing. Common applications include use with oscilloscopes, high-speed counters, pulse-height analyzers and photo multipliers.

1-3. MODELS 106, 107 DIFFERENCES.

a. The Models 106 and 107 differ only in their tuning. The Model 106 is tuned for flat response over a wide bandwidth. The Model 107 is tuned to amplify wave forms where pulse fidelity is of most importance. Otherwise, both Amplifiers are identical.

b. The instructions in this Manual are for both models. Where there are differences — such as specifications, applications and calibration — the Models are identified. The Circuit Description, Accessories, Replaceable Parts List and Schematic Diagram are identical.

1-4. ACCESSORIES. Refer to Section 6 for complete descriptions.

a. Model 1042 Accessory Kit provides useful adapters, terminations and tee for use with the Amplifier. The Kit accessories, contained in a convenient case, are described in Section 6.

b. Model 4001 Rack Mounting Kit adapts the Models 106 and 107 for standard 19-inch rack mounting. As rack models, the Amplifiers are 5-1/4 inches high x 19 inches wide x 10 inches deep.

1-5. SPECIFICATIONS.

	Model 106	Model 107
Frequency[1]: -3db ±0.5db	1 kc and 180 Mc 2.5 kc to 150 Mc	—— ——
Rise Time[2]: 10% to 90%	Less than 3 nanoseconds	Less than 3 nanoseconds
Overshoot[3]	——	Less than 2%
Pulse Width for 10% Droop	——	30 microseconds
Input Impedance	50 ohms	50 ohms
Voltage Gain (into 50-ohm characteristic impedance)	10 (20db) ±2% at 10 kc	10 (20db) ±2% at 10 kc
Maximum rms Noise[4]	30 microvolts (7db)	30 microvolts (7db)
Maximum Output (into 50-ohm characteristic impedance)	1.4 volts peak-to-peak	1.4 volts peak-to-peak
Maximum Overload	ac, 20 volts peak[5] dc, 2.5 volts	ac, 20 volts peak[5] dc, 2.5 volts
Overload Recovery[6]	Less than 50 nanoseconds	Less than 50 nanoseconds
Delay Time[7]	Less than 5 nanoseconds	Less than 5 nanoseconds
Isolation between Amplifiers	Greater than 80db at 100 Mc	
Change in Output Amplitude for a 10% Line Voltage Change	Less than ±0.1% at 10 kc, increasing to ±1% at 180 Mc.	

Notes:

1) db variations add when amplifiers are cascaded.
2) Maximum rise time for 3 amplifiers in cascade is less than 4 nanoseconds.
3) Overshoot for amplifiers in cascade is 3% or less.
4) Noise referred to input measured from 10 cps to 100 Mc. Noise of cascaded amplifiers is equal to noise of first amplifier only.
5) Continuous input power should not exceed 1/8 watt.
6) Using a 100X overload test pulse 100 nanoseconds wide with 5-nanosecond fall time to within 1% of base line. A shorter pulse duration, a slower fall time or less overload shortens recovery time.
7) Delay times add when amplifiers are cascaded.

CONNECTORS: Input and Output: n type.

POWER: 105-125 or 210-250 volts (switch selected), 50-400 cps, 30 watts.

DIMENSIONS, WEIGHT: 5-1/2 inches high x 17-1/2 inches wide x 10 inches deep; net weight, 15 pounds.

ACCESSORIES SUPPLIED: Two patch cables; mating input and output connectors.

1-6. EQUIPMENT SHIPPED. The Models 106 and 107 are factory-calibrated and are shipped with all components in place. All units are shipped for bench use. The shipping carton contains the Instruction Manual, two patch cables and mating input and output plugs.

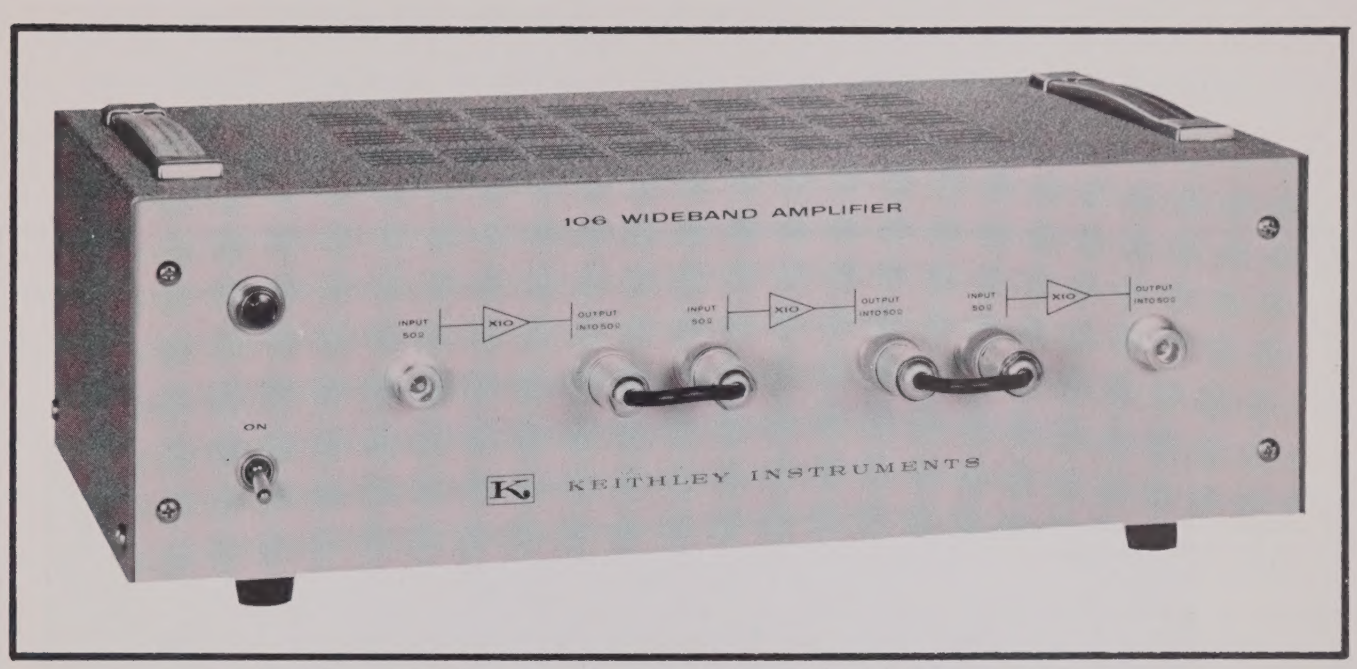


FIGURE 1. Keithley Instruments Model 106 Wideband Amplifier.

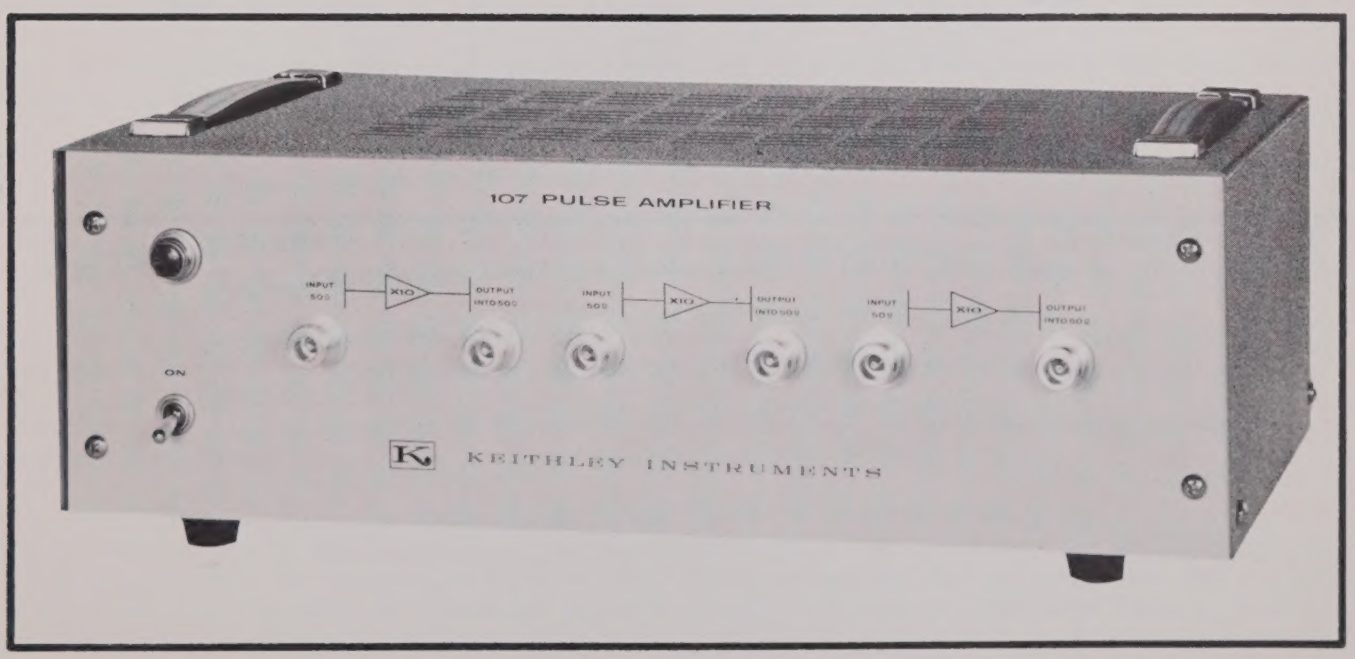


FIGURE 2. Keithley Instruments Model 107 Pulse Amplifier.

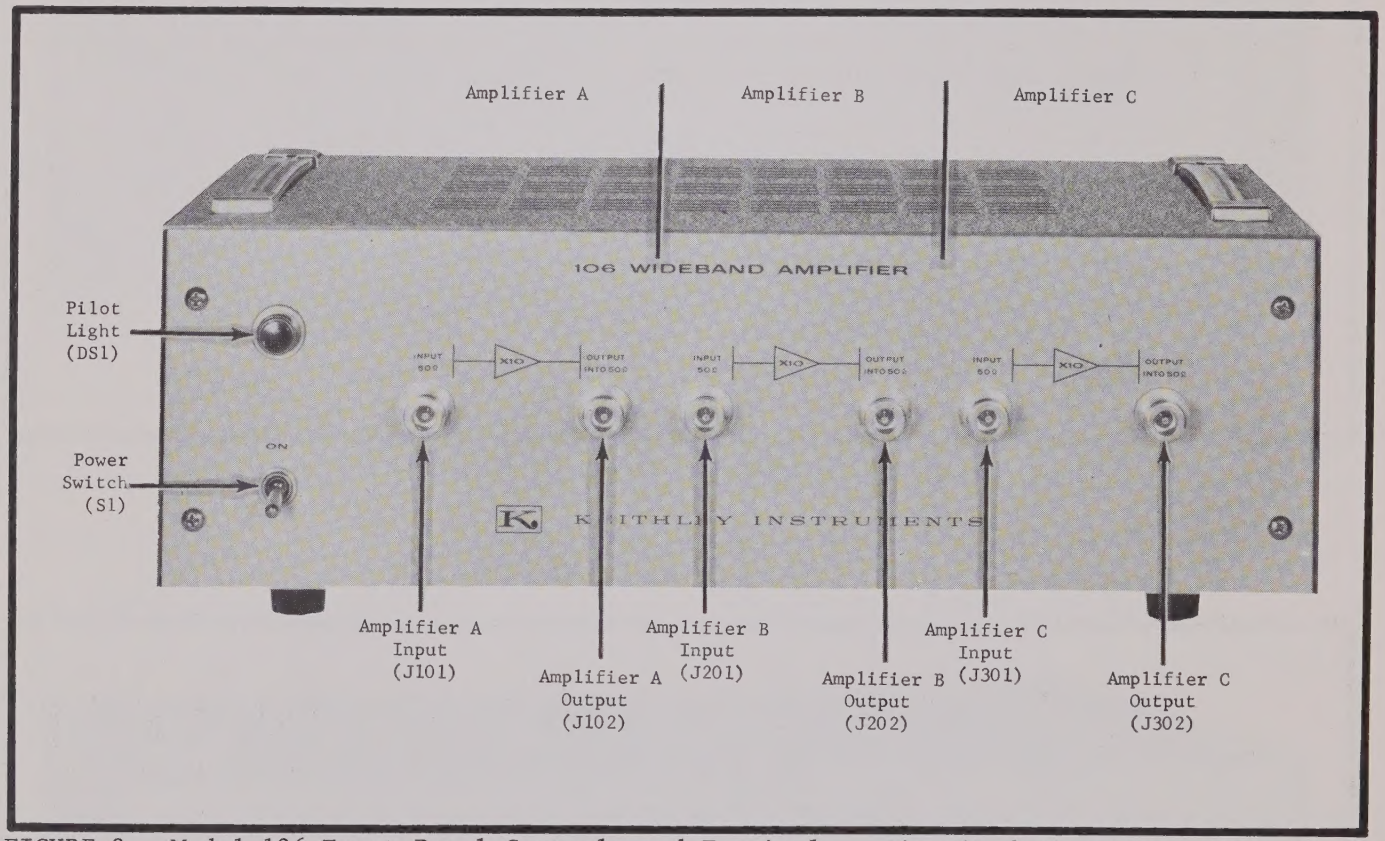


FIGURE 3. Model 106 Front Panel Controls and Terminals. Circuit designations refer to the Replaceable Parts List. The Model 107 has identical front panel controls and terminals.

SECTION 2. OPERATION

2-1. FRONT PANEL CONTROLS AND TERMINALS. (See Figure 3.)

a. Power Switch. The Power Switch is a toggle switch which turns on the Amplifier.

b. Pilot Light. The amber pilot light indicates when the instrument is on.

c. INPUT and OUTPUT Receptacles. Three sets of n-type INPUT and OUTPUT Receptacles are located on the front panel, one set for each amplifier. Impedance at the INPUT Receptacle is 50 ohms. N-type connectors are used for their better impedance characteristics and less leakage at higher frequencies than other popular connectors.

2-2. REAR PANEL CONTROLS AND TERMINALS.

a. 117-234 Switch. The screwdriver-operated slide switch sets the Amplifier for 117 or 234-volt ac power lines.

b. Pre-amplifier Power Receptacle. The Amplifiers have a 4-pin receptacle to furnish the +16 and -12 volts needed to power the Models 108 and 109 Amplifiers. These two amplifiers can be used to increase the Models 106 and 107 gains by ten.

c. Power Cord. The 3-wire power cord with NEMA approved 3-prong plug provides a ground connection for the cabinet. An adapter for operation from 2-terminal outlets is provided.

d. Fuse. For 105-125 volt operation, the Amplifier uses a 0.5 ampere, 3 AG fuse; for 210-250 volt operation, the Amplifier uses a 0.25 ampere, 3 AG fuse. The fuse is removed by unscrewing the cap and pulling out the fuse holder.

2-3. OPERATING PROCEDURES.

a. No control settings or preliminary adjustments are needed to operate the Amplifier. It can be used immediately after the instrument is turned on.

NOTE

The Models 106 and 107 have n-type receptacles (Mil. No. 680/U). Model 1042 Accessory Kit contains adapters to connect other type plugs to the Amplifier. Section 6 describes the Kit.

b. Connect the Amplifier and associated equipment, such as an oscilloscope, on the same power line to avoid ac ground loops. Otherwise, the output signal from the Model 106 or 107 will tend to be modulated by the ground loops. To further minimize ground loops, it may be necessary to use isolation plugs on power line plugs of the Amplifier and the associated equipment.

c. Use coaxial cables for connections, especially if working above 1 Mc. Up to six feet of coaxial cable may be used on the amplifier inputs and up to 12 feet on the outputs, if the output cable is terminated with 50 ohms. Longer cables may be used, but the Amplifier may not meet the flatness or overshoot specification. All cables used must have a 50-ohm characteristic impedance.

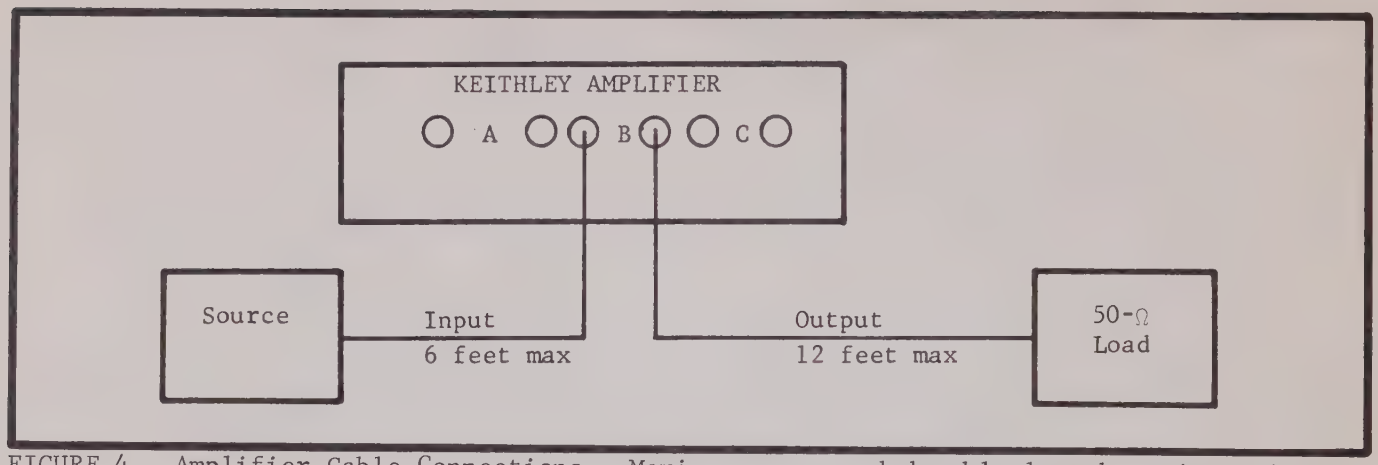


FIGURE 4. Amplifier Cable Connections. Maximum recommended cable length to input is six feet, from output, 12 feet. If longer cables are used, the specified flatness or overshoot may not be achieved. Use only coaxial cables.

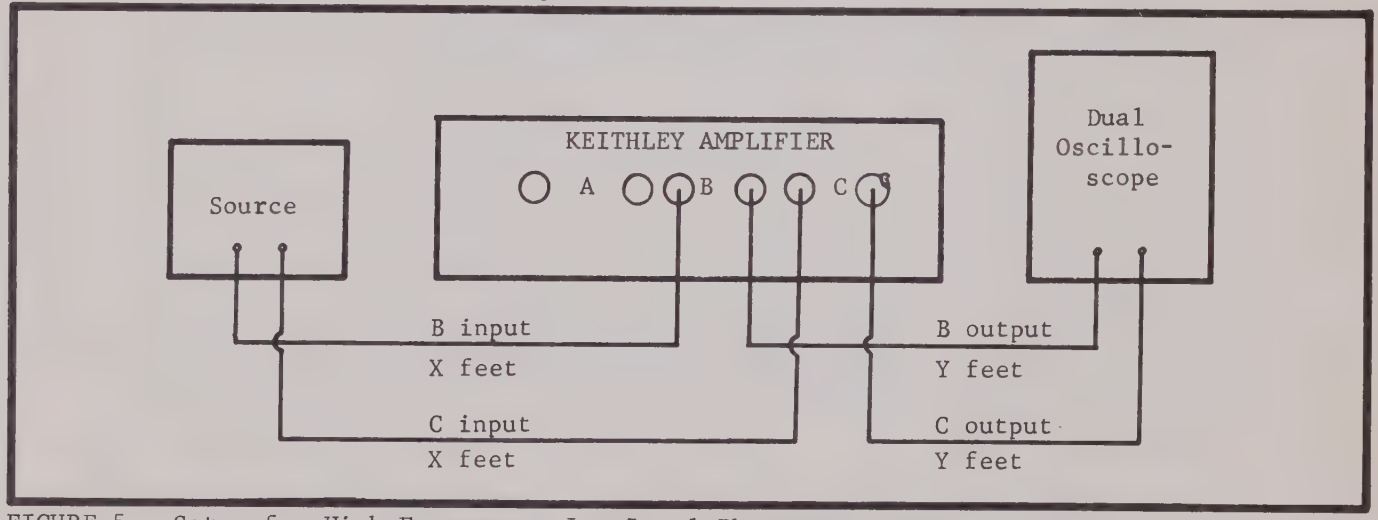


FIGURE 5. Setup for High-Frequency, Low-Level Phase Measurements. Match both input and both output cables for equal time delays. The X10 gain amplifiers have time delays within tenths of a nanosecond of each other. Measurements will be reasonably accurate if the cables are closely matched for delay characteristics.

d. For phase-shift work, use input and output cables of equal length to eliminate delay time errors.

2-4. CASCADING.

a. For proper amplifier response, cascade the amplifiers in the sequence shown on the front panel; connect A only into B, and B only into C.

NOTE

Use only the furnished patch cables to cascade the amplifiers. The cables assure proper response, and minimize high frequency switching problems caused by most mechanical switches.

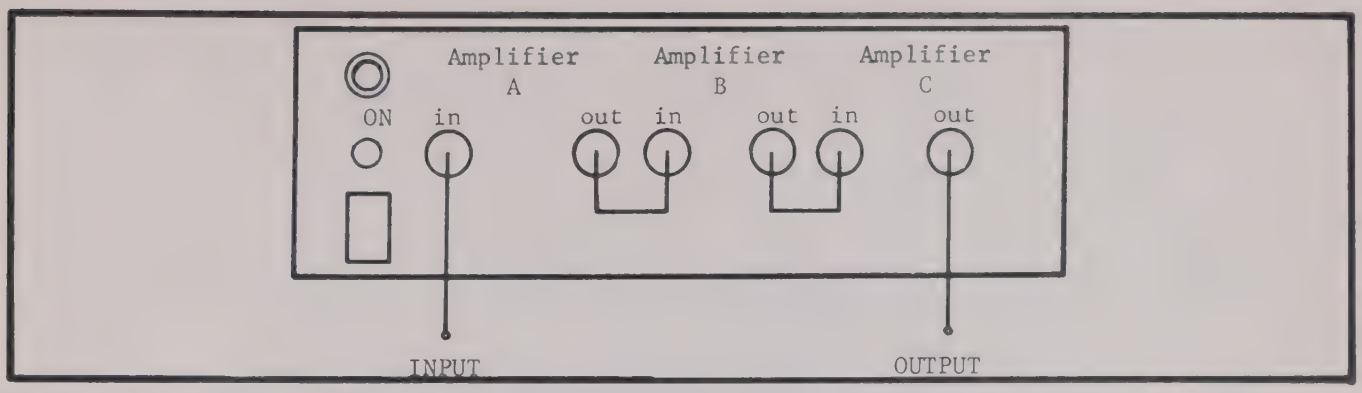


FIGURE 6. Cascading Amplifiers. Use only the provided patch cables to cascade the amplifiers. Connect the patch cables from the OUTPUT to the INPUT connectors in the sequence shown. Do not use external terminations. Using cables other than the provided patch cables may cause a deterioration of the frequency response flatness.

b. Amplifiers can be cascaded for gains of 100 and 1000. The final amplifier output should not exceed 1.4 volts peak-to-peak into a 50-ohm load. Higher outputs exceed the limits of the amplifier stages and distortions will result, such as overshoot on the Model 107.

c. Keithley Models 108 and 106 can be cascaded for a gain to 10,000; Models 109 and 107 can be cascaded for a gain to 10,000. The Models 108 and 109 are small 10X amplifiers with circuits similar to the Models 106 and 107. Connect the Models 108 and 109 POWER Receptacles to the Pre-amplifier Power Receptacle on the Models 106 and 107 back panels. This outlet furnishes the correct voltages to power the small 10X Amplifiers.

2-5. GAINS OTHER THAN 10, 100, 1000 AND 10,000. For gains in between the cascaded values, use attenuator pads in series with the Amplifier. When two amplifiers are cascaded, use the attenuator pad on the last amplifier OUTPUT Receptacle for input signals below 15 millivolts peak-to-peak for the best signal-to-noise ratio. For example, a 1-millivolt rms input signal is amplified 20 times (26db) using a 14-db attenuator pad on the last amplifier output. Maximum input noise of each amplifier is 30 microvolts rms. Noise at the last output is 3 millivolts rms. When the noise is attenuated 5 times through the 14-db pad, its level is 0.6 millivolt rms. Signal-to-noise ratio is approximately 28:1. If the 14-db attenuator pad were used at the first amplifier input, the output noise would be 3 millivolts rms. Signal-to-noise ratio would be approximately 6:1, or four times worse than previously.

2-6. OPEN CIRCUIT OPERATION. The specified Amplifier gain is into a 50-ohm load. The gain changes for an open circuit. Output impedance is approximately five ohms below 10 megacycles, increasing as the frequency increases. Below 10 megacycles, the gain into an open circuit is approximately 10.5 to 11. Above 10 megacycles, the gain increases to approximately 18 (25db) at 150 megacycles. The Amplifier will not oscillate into an open circuit at any frequency, although standing waves become apparent at the higher frequencies. The magnitude of the waves depends directly on cable length and frequency.

2-7. AMPLIFIER NOISE. The main sources of noise are the transistors and any power supply ripple. Since all noise is referred to the input, the output noise will be the amplifier input noise times the amplifier gain (10). The noise is measured at the output and referred back to the input. When two amplifiers are cascaded, the noise of the second amplifier is not significant because noise adds as the square root of the sum of the squares.

2-8. RISE TIME.

a. The rise time is defined as the time needed for a signal to rise from 10% to 90% of its final value. Specifically, for amplifiers, rise time is the time needed for the amplifier to go from 10% to 90% of the final value of the input signal times the amplifier gain. Rise time is measured only with a pulse whose rise time is faster than the amplifier's. When amplifiers are cascaded, the rise times add in quadrature (square root of the sum of the squares).

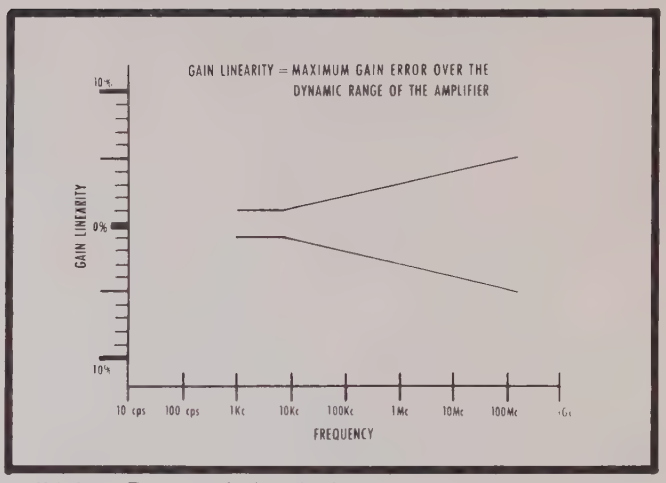


FIGURE 7. Models 106 and 107 Gain Linearity. The gain linearity falls within the limits shown above from 2.5 kc to 150 Mc.

b. The slight overshoot of a very high frequency pulse can be eliminated in the Model 106 by detuning the high-frequency response slightly. The Model 106 is tuned for maximum gain flatness for a continuous signal. The Model 107 is already tuned for minimum overshoot. (See Section 5.)

2-9. DELAY TIME. Delay time is the transient time taken by a signal to go from the amplifier input to output. It is measured from the midpoint of an input pulse to the midpoint of the output pulse. Because delay times are a physical constant, they add for cascaded amplifiers.

2-10. GROUND LOOPS. A common source of errors when amplifying low-level signals is ground loops. This is a current — line or other frequency — flowing in a ground lead impedance, which results in a voltage in addition to the desired signal voltage appearing at the input terminals of the amplifier. Although the origin and mechanism of ground loops are difficult to explain and trace, their effects can be reduced in several ways.

a. Eliminate unnecessary ground by using a 3-to-2 prong adapter to lift the instrument case from power system grounds.

b. Use a low capacitive, high insulation-resistive isolation transformer between the power line and the amplifier.

c. Make all ground lead impedances as low as possible.

d. Employ only coaxial hookups wherever possible.

2-11. STRAY FIELDS. Stray fields can induce unwanted emf's in the test system. The inaccuracies due to these fields become more significant as measurements become more sensitive. Induced emf's may be reduced by using coaxial cable having minimum loop area and by using cables of minimum length.

2-12. 234-VOLT OPERATION. If the power line is 234 volts, use a screwdriver to change the 117-234 Switch on the back panel. Change the fuse from 0.5 ampere to 0.25 ampere. No other adjustment is necessary.

SECTION 3. CIRCUIT DESCRIPTION

3-1. GENERAL.

a. The Keithley Models 106 and 107 Amplifiers consist of three identical, independent amplifiers operated from a common power supply. Each amplifier may operate independently of the others or in cascade. The Model 106 is tuned for wideband response; the Model 107 is tuned for pulse response.

b. Both Amplifiers are of conventional RC-coupled cascade design, using negative feedback. There is no inductive peaking. The wide bandwidth is achieved by using selected epitaxial mesa transistors with a 1-gigacycle f_t.

c. Careful circuit design allows for maximum performance. Point-to-point wiring minimizes lead inductance. Silver plating on the chassis eliminates ground loops and reduces resistance due to skin effect at high frequencies. Using solid-state components, hermetically sealed tantalum capacitors and metal film resistors insures excellent stability and long, trouble-free operation.

d. Each amplifier is individually enclosed for maximum isolation. Special RF gaskets are used to maintain 80-db isolation at 100 Mc.

NOTE

Refer to Schematic Diagram 17715D at the back of the Manual for circuit designations.

3-2. AMPLIFIER DESIGN. All three amplifiers have identical circuits, using three high-frequency transistors, two in common emitter cascade configuration and the third being an emitter follower for the output. A high negative feedback loop is used for gain stability.

NOTE

Amplifier A uses 100 series circuit designations; Amplifier B, 200 series; Amplifier C, 300 series. The designations used below are equivalent for all three amplifiers.

a. The input is shunted by a 50-ohm metal film resistor (R102), compensated for a nominal 50-ohm input impedance across the band. The input signal is applied to transistor Q101. Transistors Q101 and Q102 amplify the signal and apply it to the emitter follower, transistor Q103, which

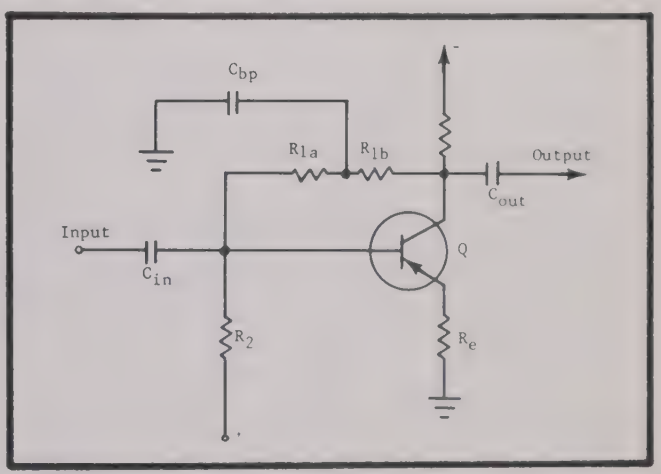


FIGURE 8. Basic Amplifier Stage. The diagram shows the stage design used in the 2-stage amplifier. Resistors R_1 and R_2 and the collector bias voltage drop provide a bias voltage divider, which stabilizes the base voltage. Resistor R_1 supplies dc feedback. To eliminate degeneration caused by the ac feedback, R_1 is divided into two parts, R_{1a} and R_{1b}. Capacitor C_{bp} bypasses the ac from the midpoint to ground.

provides low output impedance and higher power capabilities than the amplifier stages.

b. The feedback loop for the two stages is through resistor R116 and capacitor C110. The output of transistor Q102 is divided by resistor R116 and the network, resistors R109, R110 and R111. Potentiometer R111 adjusts the gain at the lower frequencies. Trimmers C103, C112, C115 and C118 adjust the feedback at higher frequencies, since the divider becomes primarily capacitive.

c. Each stage uses dc feedback from collector to base. The feedback loop for the first stage, transistor Q101, consists of two resistors, R105 and R106. Capacitor C105 is at the midpoint between the two 2.2-kilohm resistors to eliminate ac feedback. Resistors R114 and R115 and capacitor C108 provide the same function for transistor Q102.

3-3. POWER SUPPLY. The power supply furnishes -12 volts and +16 volts for biasing the amplifiers. Both outputs use similar circuits. Voltage from transformer T1 is full-wave rectified and filtered. The transformer ratio is set to furnish the two outputs.

SECTION 4. SERVICING

4-1. GENERAL. Section 4 contains the maintenance and troubleshooting procedures for the Models 106 and 107. Follow these as closely as possible to maintain the instrument's specifications.

4-2. SERVICING SCHEDULE. The Models 106 and 107 require no periodic maintenance beyond the normal care required of high-quality electronic equipment. Occasional checks of the frequency or pulse response of the Amplifier should show the need for any adjustment. No part should need frequent replacement under ordinary use.

4-3. PARTS REPLACEMENT.

a. The Replaceable Parts List in Section 7 describes the electrical components of the Amplifiers. Replace components only as necessary. Use only reliable replacements which meet the specifications. Check the frequency or pulse response after any transistor is replaced.

b. The transistors are selected for parameters which allow wide frequency response. Order these parts only from Keithley Instruments, Inc., or its representative.

NOTE

Physical location of components greatly affects high frequency response. Put replaced parts and their leads in their exact previous position. Also, make sure the gaskets around the modules are replaced properly to maintain isolation.

4-4. TROUBLESHOOTING.

a. The procedures which follow give instructions for repairing troubles which might occur in the Models 106 and 107. Use the procedures outlined and use only specified replacement parts. Make sure the external circuits are checked. Table 1 lists equipment recommended for troubleshooting. If the trouble cannot be located or repaired, contact Keithley Instruments or its representative.

Instrument	Use
Keithley Instruments Model 121 True RMS Voltmeter	Measure ac voltages
Simpson Models 260 and 650 Transistor Beta Testers	Check transistors
Tektronix Type 504 Oscilloscope, passband dc to 450 kc	Observe wave forms
DC Voltmeter, 10% accuracy, 10 megohm input resistance	Measure dc voltages

TABLE 1. Equipment Recommended for Troubleshooting. Use these instruments or their equivalents.

Trouble	Probable Cause	Remedy
Amplifier will not operate	Faulty transistor	Check Q101, Q102, Q103; replace if faulty
Improper response only with cascaded amplifiers	Faulty patch cables	Check cable; replace if faulty
Noise within amplifier exceeds 30 microvolts rms	Faulty transistor	Check Q101, Q102, Q103; replace if faulty
	Excessive ripple from power supply	Check power supply. Check filters C101, C106, C116 C122, C123, C124.
All amplifiers will not operate	Faulty power supply	Check power supply for -12 and +16 volt output, ±10%
Gain is more or less than 10	Potentiometer R111 out of adjustment	Adjust R111 per paragraph 5-3
Model 106 frequency response not flat within specifications	Amplifier out of calibration	Calibrate response per paragraph 5-4
Model 107 exceeds overshoot specification	Amplifier out of calibration	Calibrate per paragraph 5-5
Rise time of amplifier not within specification	Amplifier out of calibration	Adjust Model 106 per paragraph 5-4, Model 107 per paragraph 5-5
Input impedance not 50 ohms	Faulty R102 or C102	Check R102 and C102; replace if faulty

TABLE 2. Models 106 and 107 Troubleshooting. Refer to paragraph 4-4, b, before troubleshooting the Amplifier.

b. Before troubleshooting the Amplifier, check the external circuits. Make sure the Amplifier output is terminated into a good 50-ohm load. Check the condition of the coaxial cables and connections. Check the performance of the signal generator and other instruments. (The Amplifier will faithfully amplify any signal fed to it; a poor input results in a poor output.) Make sure the output signal does not exceed 1.4 volts peak-to-peak. If the external circuits are good, check the Amplifier itself.

c. Table 2 contains troubles which might occur with the instrument. If the repairs indicated in the Table do not clear up the trouble, continue to search through a circuit-by-circuit check. Refer to the circuit description in Section 3 to find the more crucial components and to determine their function in the circuit. The complete circuit schematic diagram, 17715D, is in Section 7.

d. If the instrument will not operate, check the fuse, line cord and power source. If these are satisfactory, continue to isolate the trouble. The Schematic Diagram indicates the transistor terminal voltages referenced to chassis ground. Measure the dc voltages to ±10% of indicated value with a dc voltmeter.

SECTION 5. CALIBRATION

5-1. GENERAL.

a. The following procedures are recommended for calibrating and adjusting the Models 106 and 107. Use the equipment recommended in Table 3. If proper facilities are not available or if difficulty is encountered, contact Keithley Instruments, Inc., or its representative to arrange for factory calibration.

b. Three calibrations are in the procedures: low-frequency calibration, high-frequency wideband calibration and pulse calibration. In addition, paragraph 5-6 outlines test procedures to check response.

c. If the instrument is not within specifications after the calibration, follow the troubleshooting procedures or contact Keithley Instruments, Inc., or its representative.

Instrument	Use
General Radio GR-874 type attenuators, 3 db, 6 db, 10 db and 20 db	High frequency calibration
General Radio GR-874-WM50 50-ohm termination (also found in Keithley Instruments Model 1042 Accessory Kit)	Amplifier termination
Hewlett-Packard Model 202A Audio Oscillator, 20 cps to 40 kc, ±2%	Signal generator for low-frequency calibration
Jarrold Electronics Model 900-B Sweep Signal Generator (includes Model D50 Detector), 500 kc to 1200 Mc	Signal generator for Model 106 band response
Keithley Instruments Model 121 True RMS Voltmeter	Measure ac voltages
Tee and adapters (found in Keithley Instruments Model 1042 Accessory Kit)	Hook up calibration circuits
Tektronix Type 111 Pulse Generator, 0.5-nsec rise time, 2 to 20-nsec pulse duration	Check pulse response of Model 107
Tektronix Type 504 Oscilloscope, passband from dc to 450 kc	Check wave form during tuning and view sweep display of Model 106
Tektronix Type 561A Oscilloscope, with dual trace plug-in sampling units, 0.4-nsec rise time	View pulse response of Model 107

TABLE 3. Equipment Recommended for Models 106, 107 Calibration. Use these instruments or their equivalents.

Control	Circuit Desig.	Fig. Ref.	Refer to Paragraph
Amplifier A high frequency	C103	15	5-4 (106) 5-5 (107)
	C112	15	
	C115	15	
	C118	14	
Amplifier B high frequency	C203	15	5-4 (106) 5-5 (107)
	C212	15	
	C215	15	
	C218	14	
Amplifier C high frequency	C303	15	5-4 (106) 5-5 (107)
	C312	15	
	C315	15	
	C318	14	
Amplifier A low frequency	R111	15	5-3
Amplifier B low frequency	R211	15	5-3
Amplifier C low frequency	R311	15	5-3

TABLE 4. Models 106 and 107 Internal Controls. The Table lists all internal controls, the figure picturing the location, and the paragraph describing the adjustment.

5-2. CALIBRATION SCHEDULE. Check the Amplifier response yearly or when transistors are changed. Refer to paragraph 5-4 (Model 106) or 5-5 (Model 107) for procedures; recalibrate completely if the response is not correct. Always recalibrate the high-frequency gain if the low-frequency gain is adjusted.

NOTE

Since the three amplifiers on the Models 106 and 107 are identical, the following calibration procedures apply to each. The circuit designations indicated are for Amplifier A (series 100 designations). Series 200 and 300 designations are equivalent for amplifiers B and C respectively.

5-3. MODELS 106, 107 LOW-FREQUENCY CALIBRATION.

a. Remove the Amplifier bottom cover.

b. Connect the Model 202A Oscillator to the Amplifier INPUT. Adjust the oscillator signal for 50 millivolts rms at 10 kc. Connect the Model 121 Voltmeter, Type 504 Oscilloscope and 50-ohm termination to the Amplifier OUTPUT. The output signal should be 500 millivolts rms $\pm$10 millivolts. Adjust potentiometer R111 (Figure 15), if necessary, for this output.

c. Monitor the output signal on the oscilloscope and check for distortion.

d. Repeat the same procedures for the other two amplifiers.

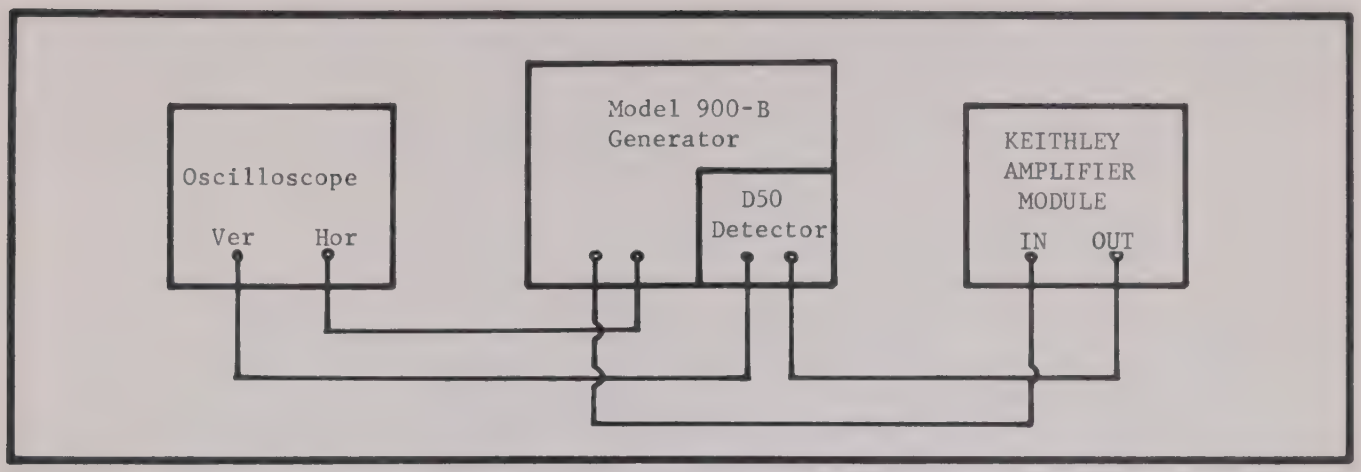


FIGURE 9. Block Diagram for Model 106 High-Frequency Calibration. Use this circuit for each of the three amplifier modules. Refer to Table 3 for equipment.

NOTE

The low-frequency calibration establishes the base for the high-frequency response. Therefore, tune the amplifier at the high frequencies after tuning it at the low frequencies. Each amplifier module is tuned independently of the other amplifier modules.

5-4. MODEL 106 HIGH-FREQUENCY CALIBRATION.

a. Remove the Amplifier top and bottom covers. Connect the Model 900-B Sweep Generator to the Amplifier INPUT directly. See Figure 9. Connect the Amplifier OUTPUT To the Model D50 Detector.

b. Adjust the generator signal to 50 millivolts rms and center the frequency at 100 megacycles. Adjust the oscilloscope for a vertical display of 5%/cm.

NOTE

Use only an insulated alignment tool in adjusting the trimmers. Dc biases are present across trimmer C118, and a screwdriver would short out the biases and possibly damage transistor Q102.

c. The low-frequency gain should be previously set (paragraph 5-3). Set trimmers C103, C112 and C115 (Figure 15) to their minimum values. Set trimmer C118 (Figure 14) to minimum by noting when the lowest high-frequency response curve appears on the oscilloscope. Set trimmer C115 to approximately 1/3 of maximum to keep the amplifier from oscillating into an open circuit at high frequencies. Set trimmer C103 near its maximum. Set trimmer C112 to approximately 1/2 maximum. The response should rise at about 50 to 100 Mc.

d. Increase trimmer C118, watching the response curve on the oscilloscope. When the response looks like a straight line — either rising or descending — stop adjusting C118. Adjust trimmer C112 to bring the high end up or down to the proper gain level. If the mid-range gain (between 50 and 100 megacycles) is not flat, alternate adjusting trimmers C103 and C118 until the response is flat. If necessary, re-adjust trimmer C112 to bring the high end in perfectly. Response should be flat to at least 150 megacycles (refer to Figure 11).

e. Insert a 3-db pad and re-adjust the oscilloscope for a vertical of 5%/cm. Check for a response of 5%. Using the oscilloscope vertical position control, put the display trace on a reference line. Remove the 3-db pad. The 180-megacycle point should be above the previously set reference line.

f. Repeat the same procedures for the other two amplifier modules.

5-5. MODEL 107 HIGH-FREQUENCY CALIBRATION.

a. Remove the Amplifier top and bottom covers.

b. Connect the Type 111 Pulse Generator to the Sampling Oscilloscope. Use attenuators (approximately 26 db) to adjust for a 0.7-volt peak pulse on the oscilloscope. Use the delay cable on the pulse generator to adjust the pulse width to approximately 20 nanoseconds. Set the oscilloscope horizontal sweep to 5 nanovolts/cm and the vertical sensitivity to 200 millivolts/cm. If necessary, use the pretrigger output of the pulse generator to synchronize the oscilloscope. Note the amount of overshoot and the shape on the pulse's leading edge.

NOTE

Make sure the pulse generator is operating properly. During this calibration, overshoot may appear on the Amplifier output which is the Amplifier faithfully reproducing the overshoot initially on the input pulse.

c. Add a tee (included in the Model 1042 Kit) and 20-db attenuator; connect the pulse generator to the Amplifier INPUT. See Figure 10. Connect the Amplifier OUTPUT to the oscilloscope's other horizontal input. Note the oscilloscope has 50-ohm input impedance, which terminates the Amplifier output.

NOTE

Use only an insulated alignment tool to adjust the trimmers. Dc biases are present across trimmer C118, and a screwdriver would short out the biases and possibly damage transistor Q102.

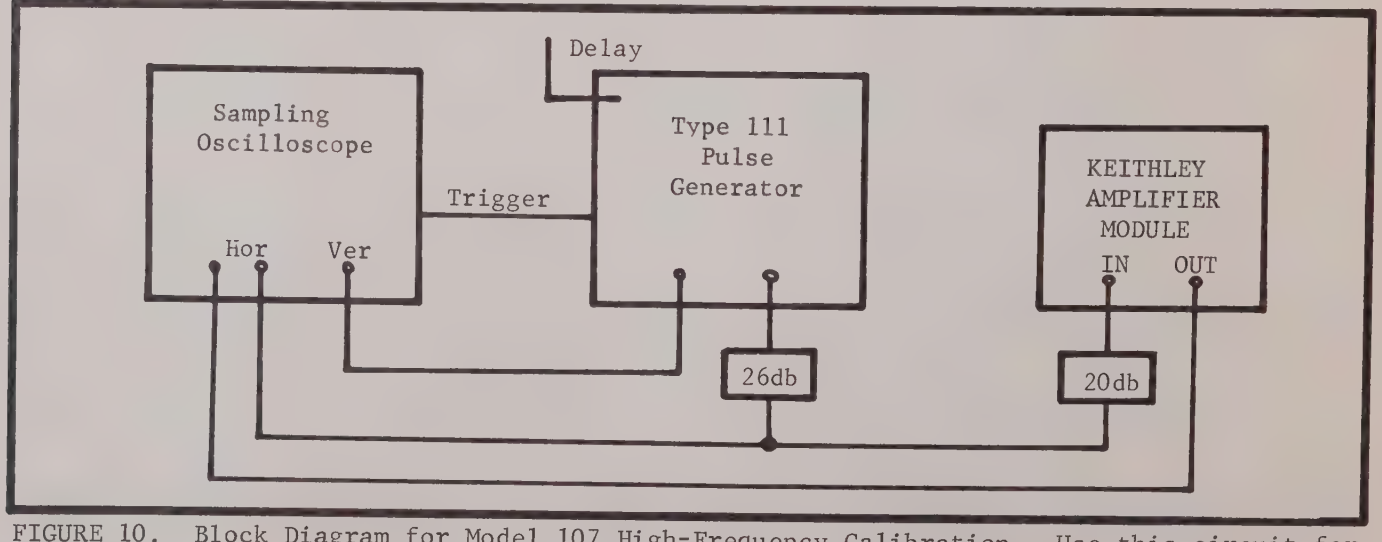


FIGURE 10. Block Diagram for Model 107 High-Frequency Calibration. Use this circuit for each of the three amplifier modules. Refer to Table 3 for equipment.

d. The low-frequency gain should be previously set (paragraph 5-3). Set trimmers C103, C112 and C115 (Figure 15) and C118 (Figure 14) to their minimum values. Set trimmer C115 to approximately 1/3 of its maximum value. Adjust trimmers C103 and C112 so that the output pulse looks exactly like the input pulse (Figure 13). If the input pulse has less than 1% overshoot and ringing, adjust trimmers C103 and C112 for less than 1% overshoot and ringing on the output pulse. Keep trimmer C118 at its minimum value.

e. Increase the oscilloscope sensitivity to 5 millivolts/cm and view the pulse tops. Slight adjustments of trimmer C115 may be necessary to make the output pulse exactly like the input pulse, except for the rise time.

f. Repeat the same procedures for the other two amplifiers.

5-6. LOW-FREQUENCY RESPONSE CHECK. Connect the Model 202A Oscillator to the Amplifier INPUT. Adjust the oscillator signal to 50 millivolts rms at 10 kc. Use the Model 121 Voltmeter to monitor the Amplifier output. Terminate the output into 50 ohms. The output voltage at 10 kc should be 500 millivolts rms $\pm$2%. Gradually decrease the signal frequency. The output amplitude should not vary more than 5% until 2.5 kc.

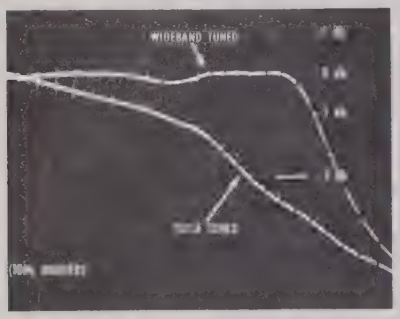


FIGURE 11. Models 106 and 107 Bandwidth Characteristics. The Model 106 is wideband tuned; the Model 107, pulse tuned. The response is from 0 cps (extreme left) to 240 Mc; each pip represents 10 Mc. Display signal of 50 millivolts rms is from a sweep generator. The excellent flatness of the wideband amplifier is gained at the expense of overshoot and ringing on pulses (see Figure 12).

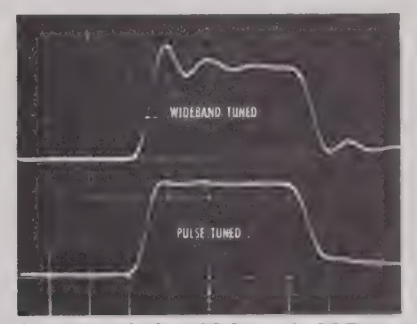


FIGURE 12. Models 106 and 107 Overshoot Characteristics. The Model 106 is wideband tuned; the Model 107, pulse tuned. The oscilloscope is set for 5 nsec/cm, horizontal, 0.2 v/cm vertical. The pulse amplifier has minimum pulse distortion at the expense of flatness (see Figure 11).

FIGURE 13 (left). Pulse Fidelity of Model 107 Pulse Amplifier. Note how the output pulse follows the input pulse.

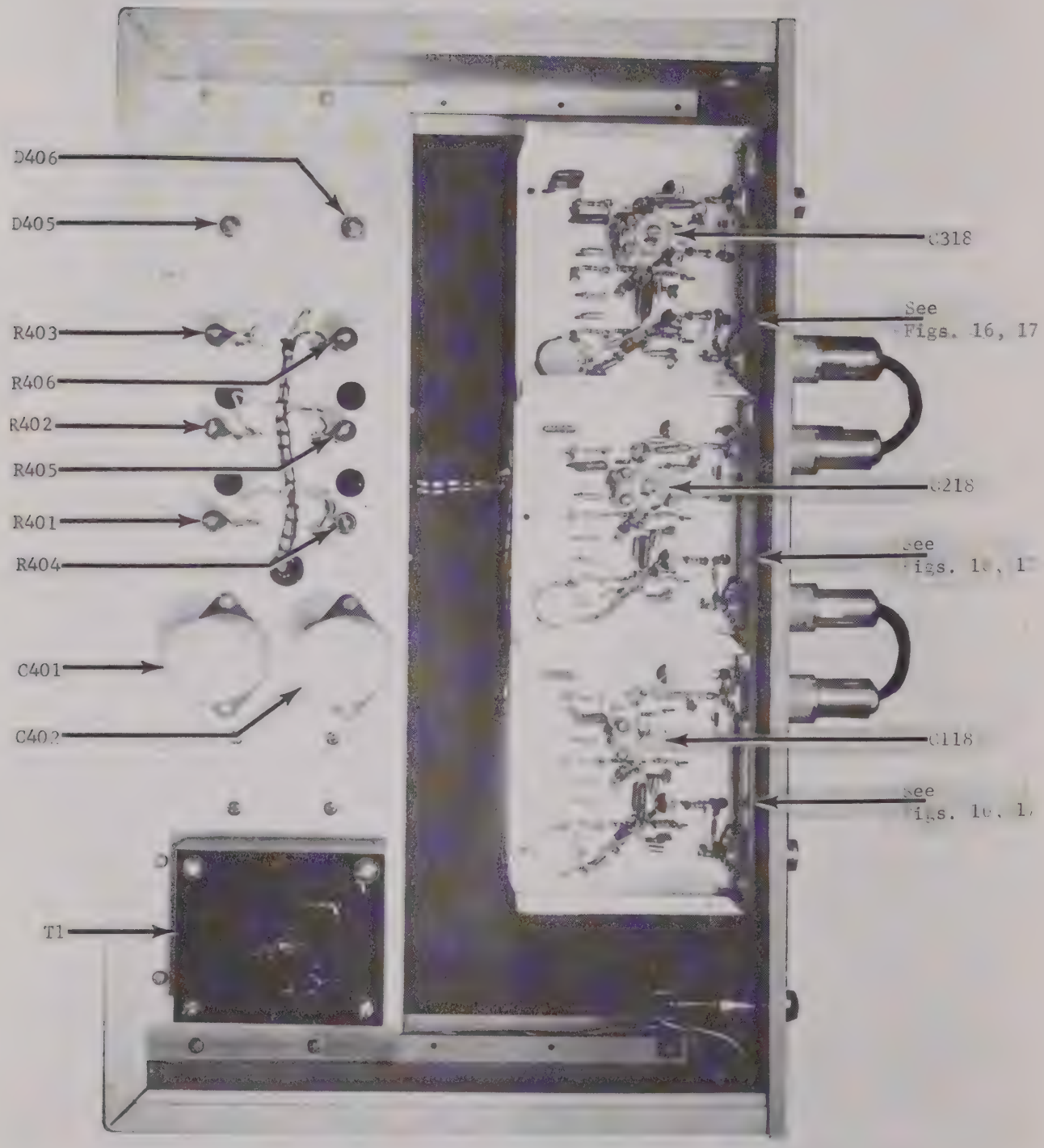


FIGURE 14. Top View of Amplifier Chassis. Inside cover over the three amplifier modules (right side) is removed. The illustration shows the location of components and amplifier modules. Both the Models 106 and 107 have the same parts locations. Refer to the Replaceable Parts List for circuit designations. Figure 15 shows the bottom view.

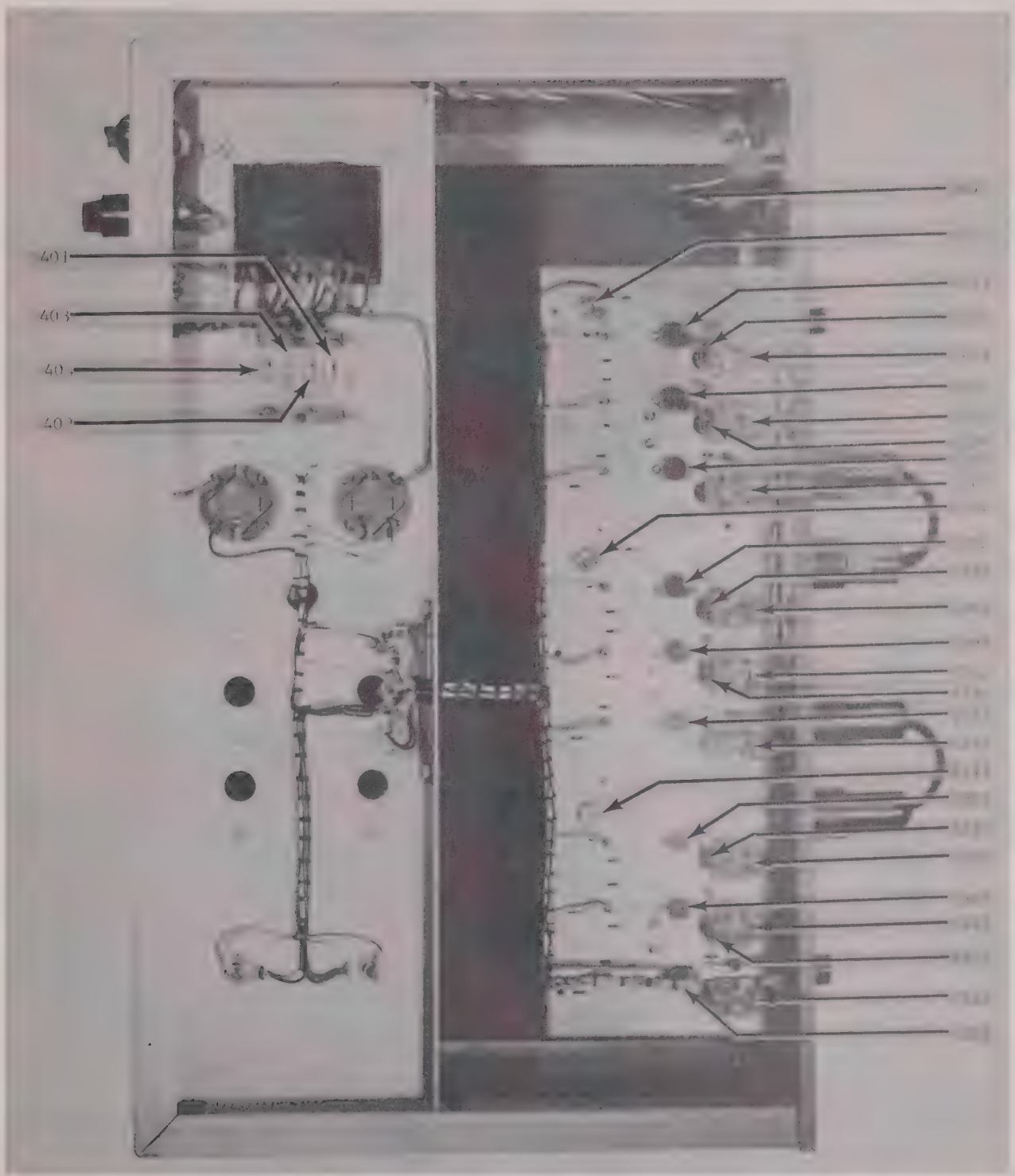


FIGURE 15. Bottom View of Amplifier Chassis. The illustration shows the locations of components. Both the Models 106 and 107 have the same parts locations. Refer to the Replaceable Parts List for circuit designations. Figure 14 shows the top view.

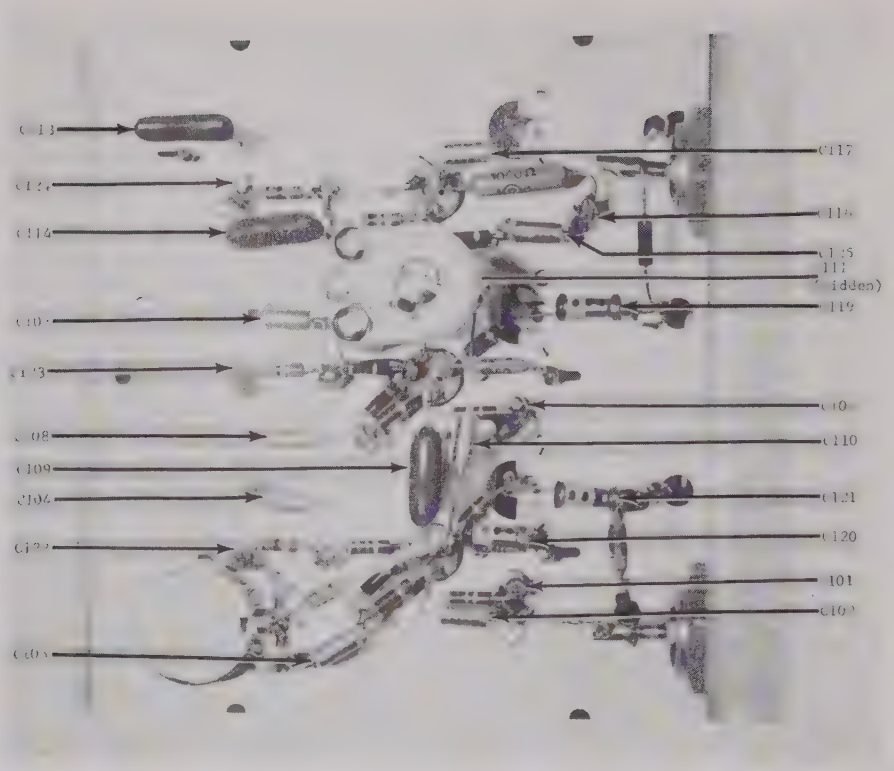


FIGURE 16. Capacitor Locations in Amplifier A. Equivalent capacitor locations in Amplifier B use the 200 series designations; in Amplifier C, the 300 series.

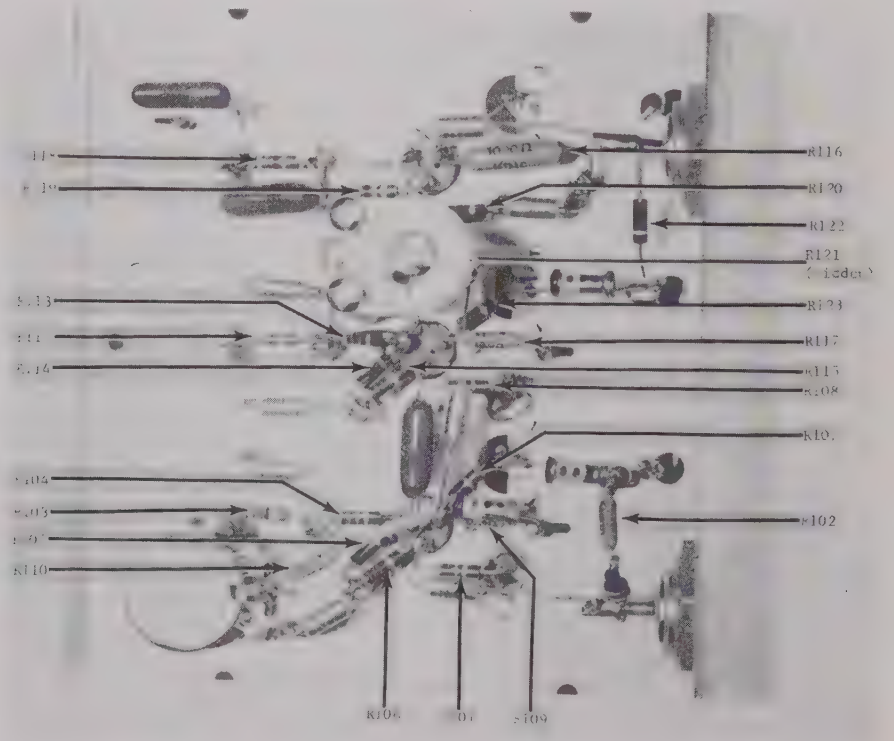


FIGURE 17. Resistor Locations in Amplifier A. Equivalent resistor locations in Amplifier B use the 200 series designations; in Amplifier C, the 300 series. Locations are the same for both the Models 106 and 107.

SECTION 6. ACCESSORIES

6-1. MODEL 1042 ACCESSORY KIT. The Model 1042 Accessory Kit provides useful adapters, a 50-ohm termination and a tee for use with the Amplifiers. The Kit case is 2 inches high x 12 inches wide x 8 inches deep with polyethylene-foam compartments. It weighs approximately three pounds.

Item, Fig. 18	Description	Keithley Part No.
1	50-ohm Termination, General Radio Type 874	CS-159
2	Adapter, male n to female uhf	CS-114
3	Adapter, male n to female bnc	CS-116
4	Adapter, male n to male n	CS-158
5	Adapter, male n to General Radio Type 874	CS-109
6	Adapter, n-type tee	CS-157
7	Adapter, male n to General Radio Type 874	CS-109
8	Adapter, male n to male n	CS-158
9	Adapter, male n to female bnc	CS-116
10	Adapter, male n to female uhf	CS-114

TABLE 5. Contents of Model 1042 Accessory Kit.

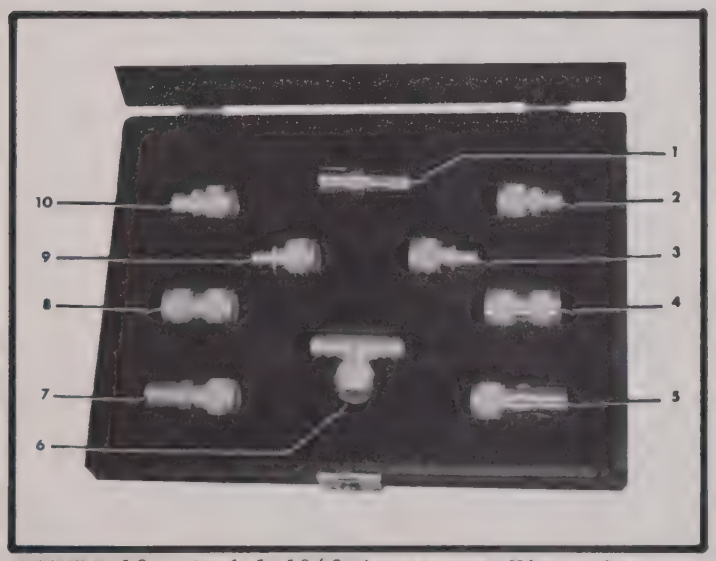


FIGURE 18. Model 1042 Accessory Kit. See Table 5 for parts.

6-2. MODEL 4001 RACK MOUNTING KIT. (See Figure 19.)

a. The Models 106 and 107 are shipped for bench use with four feet and a tilt bail. The Model 4001 Rack Mounting Kit converts the instrument to rack mounting to the standard EIA (RETMA) 19-inch width.

b. To convert the Amplifier, remove the four screws at the bottom of each side of the instrument case. Lift off the top cover assembly with the handles; save the four screws. To remove the feet and the tilt bail from the bottom cover assembly, turn the two screws near the back. The two pawl-type fasteners will release the cover and allow it to drop off. Remove the feet and the tilt bail and replace the cover (2).

c. Attach the pair of rack angles (3) to the cabinet with the four screws (4) previously removed. Insert the top cover assembly (1) in place and fasten to the chassis with the two pawl-type fasteners at the rear. Store the top cover with handles, feet and tilt bail for future use.

Item, Fig. 19	Description	Keithley Part No.	Quantity
1	Cover Assembly	17103B	1
2	Cover Assembly, Bottom (Supplied with Amplifier)	16142C	1
3	Angle, Rack	14624B	2
4	Screw, Slotted, 10-32 UNC-2 x 1/4 (Supplied with Amplifier)	—	4
5	Front Panel (Supplied with Amplifier)	—	1

TABLE 6. Parts List for Model 4001 Rack Mounting Kit.

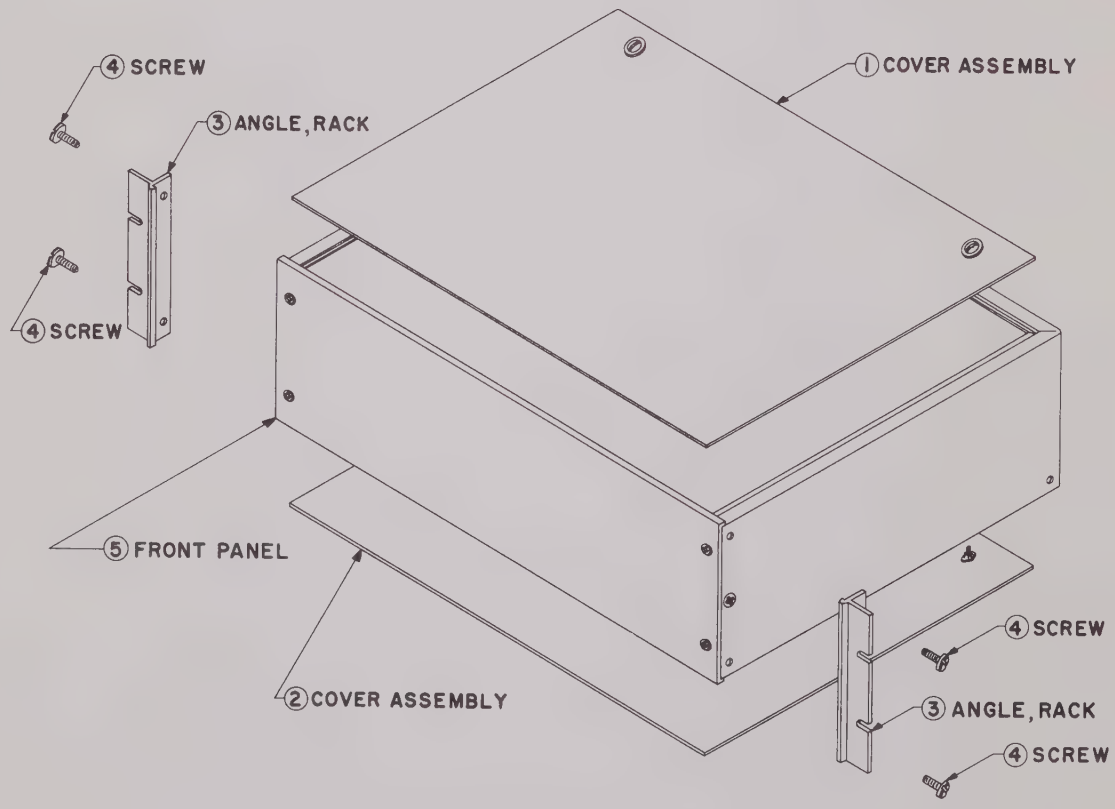


FIGURE 19. Exploded View for Rack Mounting with Model 4001 Kit.

SECTION 7. REPLACEABLE PARTS

7-1. REPLACEABLE PARTS LIST. The Replaceable Parts List describes the components of the Models 106 and 107. Both Amplifiers use the same components. The List gives the circuit designation, the part description, a suggested manufacturer, the manufacturer's part number and the Keithley Part Number. The last column indicates the figure picturing the part. The name and address of the manufacturers listed in the "Mfg. Code" column are in Table 8.

7-2. HOW TO ORDER PARTS.

a. For parts orders, include the instrument's model and serial number, the Keithley Part Number, the circuit designation and a description of the part. All structural parts and those parts coded for Keithley manufacture (80164) must be ordered from Keithley Instruments, Inc. In ordering a part not listed in the Replaceable Parts List, completely describe the part, its function and its location.

b. Order parts through your nearest Keithley representative or Sales Service Department, Keithley Instruments, Inc.

7-3. CIRCUIT DESIGNATIONS. The three X10 gain amplifiers have identical circuits and components. The schematic diagram contains the circuit for the first amplifier, using 100 series designations. The equivalent designations for the second and third amplifiers use 200 and 300 series respectively.

amp	ampere	Mil. No.	Military Type Number
		MtF	Metal Film
CerT	Ceramic, Tubular	My	Mylar
CerTr	Ceramic Trimmer		
Comp	Composition	Ω	ohms
CompV	Composition Variable		
		p	pico (10^{-12})
EMC	Electrolytic, metal case		
ETT	Electrolytic, Tantalum	Ref.	Reference
f	farad	μ	micro (10^{-6})
Fig.	Figure		
FT	Feed Through	v	volt
		Var	Variable
k	kilo (10^{3})		
		w	watt
M or meg	mega (10^{6}) or megohms	WW	Wirewound
m	milli (10^{-3})		
Mfg.	Manufacturer		

TABLE 7. Abbreviations and Symbols.

MODELS 106, 107 REPLACEABLE PARTS LIST

(Refer to Schematic Diagram 17715D for circuit designations.)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C101	500 pf	500 v	FT	71590	MFT500	C15-500P	16
C102	1.2 μf	20 v	ETT	05397	K1R2J20K	C80-1.2M	16
C103	4.5/25 pf	500 v	CerTr	71590	822AZ	C76-4.5/25P	15
C104	1.2 μf	20 v	ETT	05397	K1R2J20K	C80-1.2M	16
C105	1.2 μf	20 v	ETT	05397	K1R2J20K	C80-1.2M	16
C106	500 pf	500 v	FT	71590	MFT500	C15-500P	16
C107	1.2 μf	20 v	ETT	05397	K1R2J20K	C80-1.2M	16
C108	1.2 μf	20 v	ETT	05397	K1R2J20K	C80-1.2M	16
C109	0.1 μf	50 v	My	84411	601PE	C41-0.1M	16
C110	1.2 μf	20 v	ETT	05397	K1R2J20K	C80-1.2M	16
C111	1.2 μf	20 v	ETT	05397	K1R2J20K	C80-1.2M	16
C112	4.5/25 pf	500 v	CerTr	71590	822AZ	C76-4.5/25P	15
C113	0.1 μf	50 v	My	84411	601PE	C41-0.1M	16
C114	0.1 μf	50 v	My	84411	601PE	C41-0.1M	16
C115	4.5/25 pf	500 v	CerTr	71590	822AZ	C76-4.5/25P	15
C116	500 pf	500 v	FT	71590	MFT500	C15-500P	16
C117	4.7 μf	20 v	ETT	05397	K4R7J20K	C80-4.7M	16
C118	1.5/3 pf	500 v	CerTr	71590	822DZ	C76-1.5/3P	14
C119	10 pf	600 v	CerT	71590	TCZ	C77-10P	16
C120	*10 pf	600 v	CerT	71590	TCZ	C77-10P	16
C121	10 pf	600 v	CerT	71590	TCZ	C77-10P	16
C122	500 pf	500 v	FT	71590	MFT500	C15-500P	16
C123	500 pf	500 v	FT	71590	MFT500	C15-500P	16
C124	500 pf	500 v	FT	71590	MFT500	C15-500P	16
C125	1.2 μf	20 v	ETT	05397	K1R2J20K	C80-1.2M	16

See paragraph 7-3 for C200 and C300 series note.

C401	1000/1000 μf	35 v	EMC	37942	WP201.5	C20-1000/1000M	14
C402	1000/1000 μf	35 v	EMC	37942	WP201.5	C20-1000/1000M	14

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D401	Silicon	1N3253	02735	RF-20	15
D402	Silicon	1N3253	02735	RF-20	15
D403	Silicon	1N3253	02735	RF-20	15
D404	Silicon	1N3253	02735	RF-20	15
D405	Zener	1N2980A	04713	DZ-20	14

*Nominal value, factory set.

DIODES (Cont'd)

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D406	Zener	1N2976AR	04713	DZ-19	14

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
DS1	Neon Lamp (Mfg. No. NE-51H)	08804	PL-27	3
—	Pilot Light Assembly (Mfg. No. 81410-233)	72619	PL-5A	
F1 (117 v)	Fuse, slow blow, 1/2 amp (Mfg. Type MDL)	71400	FU-4	
F1 (234 v)	Fuse, slow blow, 1/4 amp (Mfg. No. 313.250)	75915	FU-17	
—	Fuse Holder (Mfg. No. 342012)	75915	FH-3	
J101, J201, J301	Receptacle, n, INPUT, Mil. No. UG-680/U (Mfg. No. 82-811)	02660	CS-95	3
J102, J202, J301	Receptacle, n, OUTPUT, Mil. No. UG-680/U (Mfg. No. 82-811)	02660	CS-95	3
—	(F) Plug, n, Mate of Input and Output, Mil. No. UG-536/U (Mfg. No. 309-34000)	02660	CS-96	
—	(F) Patch Cable (2 req'd)	80164	18249B	
J401	Receptacle			
	. Locking Ring (Mfg. No. 126-1430)	02660	CS-165	
	. Receptacle (Mfg. No. 126-1429)	02660	CS-163	
	. Body (Mfg. No. 126-1425)	02660	CS-161	
—	Plug, Mate of J401 (Mfg. No. 126-1427)	02660	CS-162	
P1	Power Cord, 6 feet (Mfg. No. 4638-13)	82879	CO-2	
S1	Toggle Switch, SPST, ON (Mfg. No. 20994LH)	04009	SW-4	3
S2	Slide Switch, 117-234 v	80164	SW-151	
T1	Transformer	80164	TR-81	14

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R101	47 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-47K	17
R102	50 Ω	1%, 1/8 w	MtF	07716	CEA	R88-49.9	17
R103	47 Ω	10%, 1/4 w	Comp	44655	RC07	R76-47	17
R104	470 Ω	10%, 1/4 w	Comp	01121	CB	R76-470	17
R105	2.2 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-2.2K	17

(F) Furnished accessory.

RESISTORS (Cont'd)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R106	2.2 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-2.2K	17
R107	47 Ω	10%, 1/4 w	Comp	44655	RC07	R76-47	17
R108	47 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-47K	17
R109	60.4 Ω	1%, 1/8 w	MtF	07716	CEA	R88-60.4	17
R110	100 Ω	1%, 1/8 w	MtF	07716	CEA	R88-100	17
R111	1 kΩ	20%, .2 w	CompV	71450	70	RP31-1K	15
R112	47 Ω	10%, 1/4 w	Comp	44655	RC07	R76-47	17
R113	470 Ω	10%, 1/4 w	Comp	01121	CB	R76-470	17
R114	2.2 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-2.2K	17
R115	2.2 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-2.2K	17
R116	1 kΩ	1%, 1/8 w	MtF	07716	CEA	R88-1K	17
R117	50 Ω	1%, 1/8 w	MtF	07716	CEA	R88-49.9	17
R118	47 Ω	10%, 1/4 w	Comp	44655	RC07	R76-47	17
R119	5.6 kΩ	10%, 1/4 w	Comp	01121	CB	R76-5.6K	17
R120	4.7 kΩ	10%, 1/4 w	Comp	01121	CB	R76-4.7K	17
R121	681 Ω	1%, 1 w	MtF	07716	CEC	R94-681	17
R122	1 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-1K	17
R123	10 Ω	10%, 1/4 w	Comp	01121	CB	R76-10	17
R124	Not Used						
R125	10 Ω	10%, 1/2 w	Comp	01121	EB	R1-10	15
R126	10 kΩ	10%, 1/2 w	Comp	01121	EB	R1-10K	15

See paragraph 7-3 for R200 and R300 series note.

R401	50 Ω	10%, 12 w	WW	44655	1718	R66-50	14
R402	25 Ω	10%, 12 w	WW	44655	1714	R66-25	14
R403	25 Ω	10%, 12 w	WW	44655	1714	R66-25	14
R404	25 Ω	10%, 12 w	WW	44655	1714	R66-25	14
R405	25 Ω	10%, 12 w	WW	44655	1714	R66-25	14
R406	25 Ω	10%, 12 w	WW	44655	1714	R66-25	14
R407	47 kΩ	10%, 1/2 w	Comp	01121	EB	R1-47K	15

TRANSISTORS

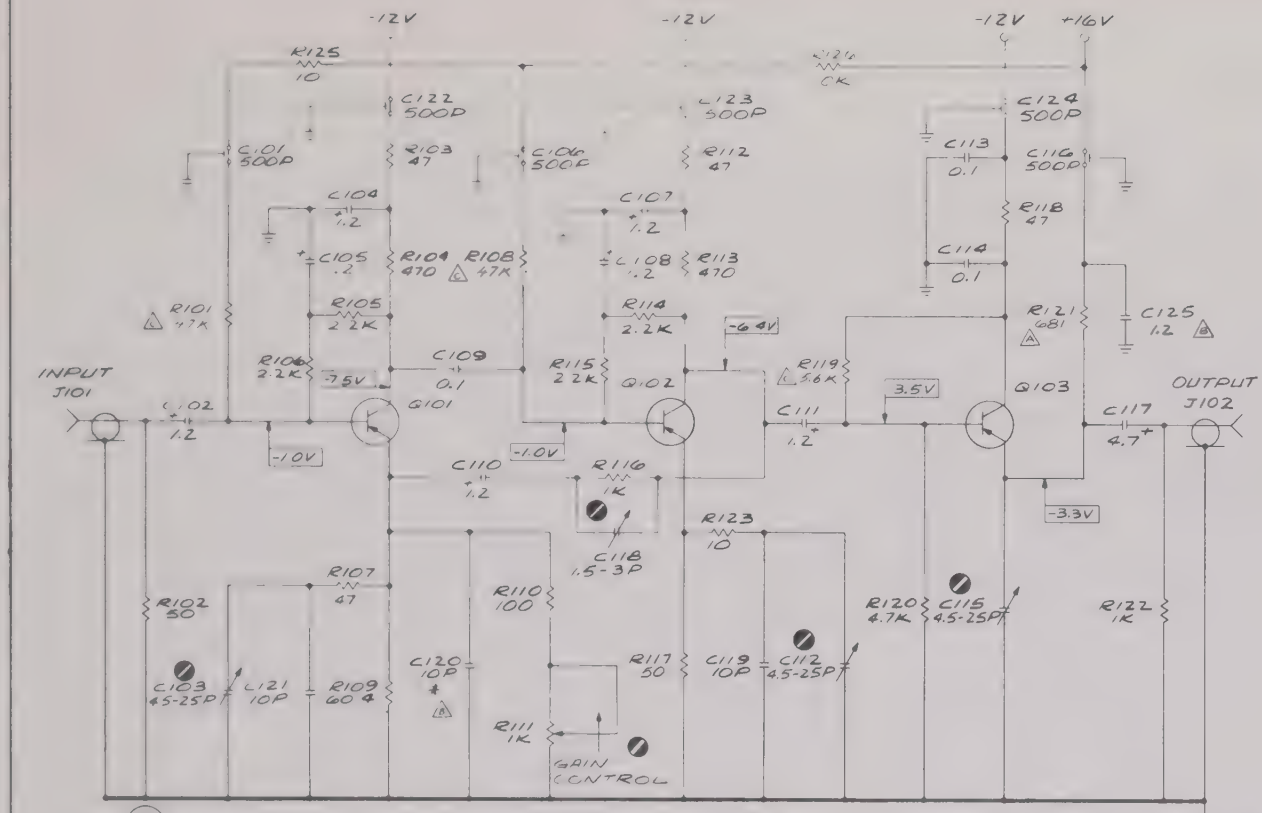
Circuit Desig.	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
Q101 (106)	SM492-1	80164	TG-17-5	15
Q101 (107)	SM492-1	80164	TG-17-3	15
Q102	SM492-1	80164	TG-17-3	15
Q103 (106)	SM492-1	80164	TG-17-6	15
Q103 (107)	SM492-1	80164	TG-17-3	15

See paragraph 7-3 for Q200 and Q300 series note.

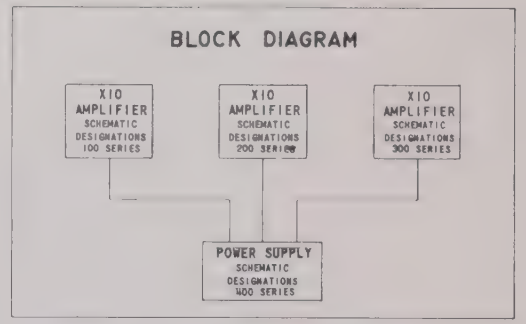
01121	Allen-Bradley Corp. Milwaukee, Wis.
02660	Amphenol-Borg Electronics Corp. Broadview, Chicago, Illinois
02735	Radio Corp. of America Commercial Receiving Tube and Semiconductor Division Somerville, N. J.
04009	Arrow-Hart and Hegeman Electric Co. Hartford, Conn.
04713	Motorola, Inc. Semiconductor Products Division Phoenix, Arizona
05397	Union Carbide Corp. Linde Division Kemet Dept. Cleveland, Ohio
07716	International Resistance Co. Burlington, Iowa
08804	Lamp Metals and Components Department G. E. Co. Cleveland, Ohio
28520	Heyman Mfg. Co. Kenilworth, N. J.
37942	Mallory, P. R., and Co., Inc. Indianapolis, Ind.
44655	Ohmite Mfg. Co. Skokie, Ill.
53021	Sangamo Electric Co. Springfield, Ill.
71400	Bussmann Mfg. Div. of McGraw-Edison Co. St. Louis, Mo.
71590	Centralab Division of Globe-Union, Inc. Milwaukee, Wis.
72619	Dialight Corp. Brooklyn, N. Y.
72982	Erie Technological Products Erie, Pa.
75915	Littelfuse, Inc. Des Plaines, Ill.
80164	Keithley Instruments, Inc. Cleveland, Ohio
82879	Royal Electric Corp. Pawtucket, R. I.
84411	Good-All Electric Mfg. Co. Ogallala, Nebr.

TABLE 8. Code List of Suggested Manufacturers. (Based on Federal Supply Code for Manufacturers, Cataloging Handbook H4-1.)

X10 AMPLIFIER
(SEE NOTE #1)



BLOCK DIAGRAM


X10 AMPLIFIER SCHEMATIC DESIGNATIONS 100 SERIES
X10 AMPLIFIER SCHEMATIC DESIGNATIONS 200 SERIES
X10 AMPLIFIER SCHEMATIC DESIGNATIONS 300 SERIES
POWER SUPPLY SCHEMATIC DESIGNATIONS 400 SERIES

NOTE:

1) ONLY ONE OF THREE IDENTICAL AMPLIFIERS IS SHOWN. SEE BLOCK DIAGRAM FOR OTHER SCHEMATIC DESIGNATIONS.
2) ALL RESISTANCE AND CAPACITANCE SHALL BE DESIGNATED IN OHMS AND MICROFARADS RESPECTIVELY, UNLESS OTHERWISE NOTED.
3) ○ FRONT PANEL CONTROL
   ⊘ FRONT PANEL SCREWDRIVER ADJ.
   ⊘ REAR PANEL SCREWDRIVER ADJ.
   ⊘ INTERNAL SCREWDRIVER ADJ.
4) ↺ = C. W. ROTATION M = MEGOHMS
   P = PICOFARADS K = 1000 OHMS.
5) ✱ INDICATES NOMINAL VALUE ADJUSTED AT FACTORY.

KEITHLEY INSTRUMENTS CLEVELAND OHIO

TITLE SCHEMATIC, AMPLIFIER

PART NUMBER 17715

DO NOT SCALE

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof (except tubes and batteries) which, within a year after shipment, proves defective upon examination.

To exercise this warranty, contact your Keithley field engineering representative. You will be given assistance and shipping instructions.

REPAIRS AND RECALIBRATION

Keithley Instruments and its international distributors maintain complete repair facilities.

To insure prompt repair or recalibration service, please contact your Keithley field representative before returning the instrument.

Estimates for repairs, normal recalibrations, and calibrations traceable to the National Bureau of Standards are available upon request.

KEITHLEY INSTRUMENTS, INC.
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